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Magnetism and Other Properties of Stainless Steel

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Ever wondered if stainless steel can be magnetic? Curious about the various grades and properties of stainless steel? Below are answers to commonly asked questions regarding the magnetism, corrosion resistance and heat-treatment of stainless steel.

Can stainless steel be magnetic?

Yes to varying degrees. The magnetism of stainless steel is affected by its alloying elements, atomic grain structure, and the amount of cold-working during fabrication.

What are 18-8, 300-Series and 400-Series stainless steels?

The American Iron and Steel Institute (AISI) has created widely accepted grades for stainless steels. These grades are identified by series numbers 100 through 600 where each series is organized by alloy and grain structure properties.

Most common to the electronics fastener industry are 300-series and 400-series stainless steels. The 300-series steels have an "austenitic" metallic grain structure while 400-series have "ferritic" or "martensitic" structures.

Among other alloying elements, several 300-series stainless steels contain approximately 18% chromium and 8% nickel. Thus "18-8" is a loose characterization of stainless steel grades 302-305, 316, 321 and 347. Even more general is the acronym "CRES" which typifies any corrosion-resistant steel.

What grades of stainless steel are magnetic?

One of the alloying metals, chromium, causes stainless steel to have a magnetic grain structure. Another of the possible alloying elements, nickel, reduces or inhibits magnetic properties. The 300-series stainless steels have varying degrees of nickel making them mostly non-magnetic. Devoid of nickel and with a grain structure similar to carbon steel, the 400-series stainless steels are slightly magnetic.

What causes non-magnetic grades of stainless steel to become magnetic?

In their basic forms stainless steels have a ferritic grain structure, similar to carbon steel, and are magnetic. The addition of nickel in the 300-series stainless steels modifies the crystal grain structure to austenitic. The austenitic grades are mostly non-magnetic in the unworked state due to their nickel content. When 300-series stainless steels are cold-worked, straining of the atomic lattice structure in the areas of cold-working forms the magnetic grain structure martensite.

Generally speaking, the higher the nickel content the more stable the austenitic structure and less magnetic response from cold-working. Consequently 316 stainless steel, with higher amounts of nickel, exhibits virtually no magnetism after cold-working in most cases. While 304, with lower nickel content, may become mildly magnetic.

Are there any means of reducing or eliminating the magnetic properties of stainless steel?

Austenitic (300-series) stainless steels that have become magnetic due to work hardening can be returned to a non-magnetic state through annealing or stress-relieving. Brief heating at elevated temperatures reverts the affected grain structure from the martensitic state to the austenitic. Since 400-series stainless steels are entirely ferritic or martensitic, their magnetic properties cannot be reduced through annealing.

There are no plating or finishing processes, such as passivation, that can reduce or eliminate work hardening induced magnetism. They are merely superficial and do not change the affected grain structure.

Is magnetism related to corrosion resistance?

Stainless steel, like carbon steel, can rust when exposed to air. However, the chromium in stainless steel forms a protective chromium oxide layer (also known as passivation) which prevents the development of iron oxide rust. The chromium oxide layer is so thin that it is imperceptible and thus the metal retains its attractive finish.

The 300-series stainless steels have a higher chromium content than the 400-series stainless steels, as well as, nickel as an alloying element. Nickel enhances chromium's ability to form a passive surface layer. Consequently, 300-series stainless steels exhibit better corrosion resistance. Corrosion resistance is a function of the chromium and nickel content and not the metallic grain structure which causes magnetism.

Is stainless steel heat treatable?

Carbon can be added to stainless steel creating a martensitic crystal grain structure. These stainless steels, such as 410 and 416, respond well to heat-treating. Although not heat-treatable, 301 stainless steel work hardens easily making it useful in applications requiring high tensile strength.

How do I know which stainless steel to specify in my application?

The table below highlights the general usage and property characteristics of stainless steels commonly used in the electronics fastener industry.

AISI Grade	Most Suitable Manufacturing Process				Property					
	Drawing & Stamping	Machining	Cold Forming	Welding	Corrosion Resistance			Heat Treatable	Non-magnetic after Annealing	Magnetic
					Good	Excellent	Superior			
301/302	●		●	●		●			●	
303		●				●			●	
304			●	●		●			●	
316	●			●			●		●	
410	●		●	●	●			●		●
416		●			●			●		●

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